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TECHNOLOGICAL INDEPENDENCE AND PROGRESS OF STANDARDIZATION IN THE JAPANESE RAILWAYS

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This paper is being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

THE Japanese railways achieved remarkable progress from the 1890s through the first decade of the twentieth century, as illustrated by a comparison of the following statistics.

Particularly, notable is the extension of the kilometerage by 2.5 times and the 9.5-fold increase in the volume of freight carried. The two decades saw two major wars, the Sino-Japanese War of 1894–95 and the Russo-Japanese War of 1904–5. The progress of an industrial revolution was also witnessed primarily in the spinning sector, which induced the nation to switch to a heavy industrial structure centering around iron and steel manufacturing. The simultaneous development of a capitalistic economy and that of the railways seems to have had an accelerating effect one upon the other. Thus, it can be seen how an economic system and the railways developed in a relationship of mutual stimulation. The Japanese railways came to hold the leading position as a means of land transportation in this period. In 1906, the Railway Nationalization Law was promulgated and as a result by 1907, seventeen privately owned railways constituting trunk lines were all nationalized. This brought about the organization of a network of state-owned railways.

The nationalization of the railways is not the subject of this paper, rather the writer would like to trace the process by which the Japanese railways achieved technological independence in those years. Particular emphasis will be placed on the completion phase because expanding the nation's transport capacity to meet the aforementioned economic needs required full technological independence. Tracing the process of the Japanese railways which gained technological independence in this framework places the observer at a basic point from which to analyze the correlationship between the capitalist economy which demanded a greater transport capacity and the railways which had to meet the demand.

Moreover, as will be referred to later on, this demand for a greater transport capacity always was a complex of two major factors, economic and military. This complex also influenced in diverse ways the standardization process which

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TABLE I

	1892	1907
Kilometerage	3,107.2	7,807.5
No. of stations	425	1,307
No. of locomotives	318	2,305
No. of passenger cars	1,376	4,833
No. of freight cars	4,565	44,583
No. of passengers carried	28,464,000	142,317,000
Tonnage of freight carried	2,717,000	25,913,000

Sources: Japanese National Railways, *Tetsudō tōkei nempō* [Annual report of railway statistics] (1916), etc.

took place side by side with the development toward technological independence.

The progress of standardization, which was the result of autonomous efforts by the Japanese railway industry, had the effect of further facilitating technological independence which had been increasingly achieved in every aspect of the construction and operation of the railways. When Japanese heavy industry had sufficiently developed so that it could supply the rolling stock and machinery which the nation's railways needed, the latter achieved full technological independence. Inasmuch as this was the relationship that evolved between technological independence and standardization, some important landmarks on the road to technological independence will be discussed in the following chapters.

I. LANDMARKS ON THE ROAD TO TECHNOLOGICAL INDEPENDENCE

The developments which can be considered important landmarks in the process toward technological independence from the 1880s through the first decade of the twentieth century will be enumerated first, and the factors which contributed to these developments will be outlined in Chapter II.

A. *Long Tunnel Ventures*

The Japanese Archipelago is topologically characterized by the dominance of mountainous areas. The obstacles posed by the mountains, though usually absent in the construction of short-range railways between nearby cities, had naturally to be overcome when the time came for the construction of medium and long-range railways, such as the trunk line connecting Tokyo, Osaka, and Kobe and lines crossing the mainland, which had been envisaged from the outset. In this section, the progress of tunnel excavating techniques alone will be discussed, and other problems involved in the construction of railways in mountainous areas will be taken up in a separate section.

The Ōsakayama Tunnel between Ōtsu and Kyoto, completed in 1880, was the first Japanese-built railway tunnel, which was followed in 1885 by the 1,352-meter long Yanagase Tunnel between Nagahama and Tsuruga. In 1893, twenty-six tunnels were excavated between Yokokawa and Karuizawa, one of which is 546 meters long. Further in 1899, a number of tunnels were completed between Fukushima and Yonezawa to cross the Itaya Pass. Integrating the experience gained through the excavation of these tunnels, a considerable number of long tunnels were built between Hachiōji and Kōfu.

Worthy of particular note among the above was the 4,657-meter Sasago Tunnel between Sasago and Hajikano, which took nine years to complete, from 1893 to 1902. During the execution of these projects, the process of excavation was steadily mechanized by the use of dynamite and other explosives, along with electric illumination within the tunnels supplied from power plants constructed nearby. Much was also removed by locomotive-driven cars. Although even the longest of these tunnels was still far shorter than the 20-kilometer Simplon Tunnel under construction at about the same time, Japanese technology for excavation of long tunnels was practically established in that period, and by the early 1910s, even the feasibility of driving an underwater tunnel crossing the Kammon Strait began to be studied.

B. *Construction of Mountainous Lines*

As stated in the foregoing section, substantial parts of the railway lines planned for construction in and after the 1880s had to pass mountainous areas. Unlike those laid on flat land, tracks in these areas were subject to severe limitations as to curves and grades, and structurally involved large-scale civil engineering processes including banking and cutting. They further required building of such structures as tunnels and bridges, which were beyond the capacity of traditional technology. Thus, these projects challenged the standards of Japanese civil engineering techniques.

In 1883, mainly in compliance with the request of the Army, the government decided to build a railway connecting Tokyo to Osaka and Kobe. Rejecting the concept of the Tōkaidō line which would run along the Pacific coast, the Army insisted on a Nakasendō line which would pass the mountainous area of central Honshū, as it anticipated the landing of enemy troops on the Pacific coast in case of a war. The routing of the Nakasendō line was supposed to be relatively easy because E. V. Boyle, a hired British chief engineer, had completed a pertinent field survey in the 1870s.

It was nevertheless expected to be a task of considerable difficulty to elevate a railway track to a height of 1,010 meters above sea level having a distance of 100 to 150 kilometers from the coastline. It would require a combination of continual steep grades of 25/1,000, switch-back stations, and hairpin bends. Additionally, from Yokokawa at the north-western corner of the Kantō plains, 386 meters from the sea level, to Karuizawa, similarly 924 meters, over the Usui Pass, a difference of some 500 meters in level had to be covered in a horizontal distance of 11.1 kilometers. After a comparison of many conceivable alternatives, it was eventually decided to build the track at a steep grade of 66.7/1,000 with the Abt type rack-rail, which had been used on funicular railways in Switzerland and Germany.

Although the project was accomplished under the guidance of a hired British engineer A. W. Pownall, the designing and construction of twenty-six tunnels, long and short, and bridges, some of which had over 10-meter long piers, were solely achieved by Japanese.

In 1886, at the strong insistence of Masaru Inoue, chief of the government Railway Bureau, the scheme for the Nakasendō trunk line was replaced by that of the Tōkaidō trunk line, and as a result the mountainous line crossing the Usui Pass was no longer a part of the trunk line. The technical standards attained by that time, however, were utilized in all subsequent railway construction projects, both governmental and private.

By the 1890s, adequate technical knowledge and experience had been accumulated to overcome the considerable topological difficulties encountered in building mountainous lines in different parts of the country, including Japan Railway Company's Tokyo-Aomori line (the construction of which was entrusted to the government) and the state railways' Chūō Line (Hachiōji-Nagoya) and Ōu Line (Fukushima-Akita-Aomori). Moreover, as stated above, a technical breakthrough had been attained, making it possible to go through mountains by digging long tunnels, rather than to lay curved tracks around them.

C. *Test Production of Steam Locomotives*

In October 1892, the state railways' Kobe workshop embarked upon the test production of a 1B1 type tank locomotive under the guidance of locomotive superintendent R. F. Trevithick then stationed in Kobe. Equipped with duplex cylinders for high and low pressures, then used in the United Kingdom, the 9,652-millimeter long locomotive, weighing 40.7 tons when fully readied for operation, was completed on May 26, 1893. As Japan at that time had no modern iron works, its underframe plates, low-pressure piston, and steel pipes had to be either ordered from Britain or derived from the local stock of British products. However, such castings as the high-pressure piston, cylinders, and axle boxes were made at the Kobe workshop. In his report (R. F. Trevithick, *Locomotive Building in Japan,* Proceedings, Inst. of Mechanical Engineers, 1895), Trevithick attached significance to the fact that these components were produced by Japanese engineers and workers at the Kobe workshop where only one foreign foreman was present.

After that, Hokkaidō Coal Mine Railways in 1895 and San'yō Railways in 1896 produced one locomotive each on a trial basis, and in 1901, Rolling Stock Manufacturing Company started manufacturing locomotives. As the Japanese Government established its tariff autonomy and raised the import duties on machinery in July 1911, the import of locomotives was discontinued with rare exceptions. In the meantime, the State-run Yawata Iron Works had been in operation and apart from Rolling Stock Manufacturing Company, others began to produce locomotives such as Japan Rolling Stock Company, Kawasaki Dockyard, and the Kobe Shipyard of Mitsubishi Heavy Industries.

D. *Mastery of Train Scheduling and Operation Knowhow*

There is a story told to this day among railway experts in Japan. In the early days of the Japanese railways, train scheduling was the task of, and kept secret by, British expert W. F. Page. Since 1874, as traffic manager, Page had supervised train scheduling and operations. He mapped out the schedule by himself in his office, to which no one would be admitted, and only after his diagram was complete would he show it to his staff. By following the schedule he prepared, trains ran safely and punctually. No one else could understand how this was possible.

One day, however, Page forgot to lock his office when he went out. A number of Japanese officials then passed by, and one of them thought of peeping into "Dr. Page's secret." His desk drawers were not locked either. The Japanese official discovered some train diagrams in one of the drawers. The secret was unveiled. It was just like Columbus's egg. One had only to plot the distance on the vertical and the time on the horizontal axis, and to plan the train trips on that basis.

The oldest train diagram now kept in the Japanese National Railways' archives dates back to the latter half of the 1890s. Page's secret presumably was revealed to the Japanese staff in the first half or the middle of the 1890s, although there is no way of knowing exactly when. When he resigned his office in March 1900, Page had been treated as an Emperor-appointed officer (comparable to bureau directors-general in ministries), paid a monthly salary of ¥720 (the Prime Minister's was ¥800 then) and invested with the Third Order of the Sacred Treasure.

How much truth there is in this story is unknown. Hired foreign experts were generally generous in imparting their technical knowhow, and would rarely, if at all, keep it secret. It is therefore hardly believable that Page would have concealed his diagramming technique.

Apart from that story, it seems reasonable to presume that the Japanese had mastered train scheduling techniques and had also become independent in operation techniques including signal handling and track maintenance by the mid-1890s.

II. BACKGROUND OF TECHNOLOGICAL INDEPENDENCE (1)

As stated above, one may safely conclude that the Japanese railways had achieved technological independence by the early 1910s, the final phase of the process being the full local production of steam locomotives. (Of course, this general statement is not without exceptions. When 50-kilogram rails, three-cylinder steam locomotives, and electric locomotives of various types subsequently began to be used, they were at first imported as finished products, until the mid-1920s. But even they were imported as models for the later establishment of mass-production systems.)

It is an interesting task to seek for the factors that accelerated this process toward technological independence. The secret of technological progress cannot be fully unveiled without clarifying its social background. Especially Japan, a capitalist state which had started later on the road to industrialization than the so-called big powers, had to set as her national goal the objective of reducing the lag behind the early starters with the slogan of "Catch up and outrun."

At work, there were not just the needs stemming from the industrial revolution. Important along with those economic needs and sometimes even more decisive were military requirements.

From this standpoint, let us analyze first the economic, and then the military factors which contributed to the increase in transport demand.

A. *Industrial Revolution and Expanded Marketing of Goods*

As pointed out at the beginning of this paper, the annual number of railway passengers quintupled in sixteen years, from about 28,460,000 in 1892 to 142,-320,000 in 1907. The increase in yearly rail-borne freight traffic was even greater, a 9.5-fold expansion over the same period from 2,720,000 tons to 25,910,000 tons. The freight which was nearly double that of passenger traffic deserves particular note. It vividly indicates the impact of the industrial revolution on the railways.

The number of factories, quantity of raw material required, and the output of, for instance, the cotton spinning sector which played the central role in the industrial revolution of Japan from the 1890s on changed in those years as listed below.

The raw material supply had come to depend heavily on imports, but only a small proportion of it was carried by rail because most of the spinning mills were located close to seaports. However, a large part of both domestic and export shipments were rail-borne, presumably because quick transport was required. In 1908, 97,982 tons of raw cotton and 110,493 tons of cotton yarn were hauled by rail.

The importance of railways was all but decisive to the shipping of raw silk, one of Japan's major exports in those days. Cocoon and raw silk producing areas were scattered in such mountainous prefectures as Nagano, Gifu, Fukushima, and Yamagata, and highways and railways were depended upon for the conveyance of these products to seaports and domestic marketing centers. Moreover, since market prices widely fluctuated, cocoons and raw silk had to be quickly shipped.

The point above can be illustrated by taking the Suwa area in Nagano Prefecture as an example. In 1893, the track over the Usui Pass was completed and this paved the way for direct rail service between Tokyo and Ueda. Thus, shipments from Suwa could now be conveyed by way of the Nakasendō route to Ōya or Ueda and eventually to Yokohama much more quickly than by the previous Kōshū Kaidō route. Silk manufacturers in the district, however, repeatedly petitioned for the construction of another railway along Kōshū Kaidō to reach Hachiōji, the present day Chūō Line. Even after the outbreak of the Russo-Japanese War in 1904 invited stagnation of railway construction in many parts of the country, these merchants again requested the early building of the line on the ground that the activation of their export marketing, which the new rail service would bring about, would help earn war funds. Eventually, they succeeded in having the Chūō Line opened in 1905 to the great benefit of their district. The raw silk output of the Suwa area increased significantly after the

TABLE II

	No. of Factories	Raw Material Required (kg)	Cotton Yarn Output (kg)
1888	24	6,776,535	6,562,927
1893	40	43,242,401	45,537,259
1898	77	159,542,460	141,383,756
1903	76	170,705,208	166,925,486
1908	86	185,612,419	182,360,164

Source: Tetsudō-in [National Railway Authority], *Hompō tetsudō no shakai oyobi keizai ni oyoboseru eikyō* [Impact of the Japanese railways on society and the economy] (c.1906), p. 925.
Note: The raw material quantities and output are translated from *kan* (traditional Japanese unit) into kilograms.

opening of the new railway, from 686,220 kg in 1905 to 1,408,496 kg in 1910.

In the coal mining industry, the annual output which stood at 342,098 tons in 1893 sharply increased to 10,088,312 tons by 1903 and 14,824,580 tons by 1908. Coal mines were widely scattered across the country, from Sorachi and Yūbari in Hokkaidō and Iwaki in Fukushima Prefecture to Chikuhō in Northern Kyūshū and some parts of Nagasaki and Saga prefectures. Transport of coal from mines to loading ports and from ports around big cities to coal-burning factories and other business establishments was the task of the railways.

Both the first railway in Hokkaidō (between Horonai and Temiya) and Japan Railway Company's Iwaki Line (the present-day Jōban Line of the JNR) were mainly intended for coal transport, and a rail network, as dense as those found in and around the big cities, was established in the Chikuhō coal mine district during the first decade of this century.

The combined annual haulage of coal by the railways ranged from 10 million to 15 million tons, accounting for 40 to 50 per cent of the total of all freight items. This large percentage taken up by coal transport was symbolic of the industrial revolution then in progress.

B. *Requirements of Military Transport*

Besides these economic factors, not to be overlooked are the military factors that underlay railway development in Japan. In those decades, the nation experienced two major wars, the Sino-Japanese War of 1894–95 and the Russo-Japanese War of 1904–5. Railways played an important role in transporting expeditionary forces to their departing ports in Japan.

Immediately, prior to the outbreak of the Sino-Japanese War, San'yō Railway Company's trunk line (the present-day San'yō Trunk Line of the JNR) had reached Hiroshima, thereby connecting Aomori to Hiroshima by rail. Though the Aomori-Hiroshima railroad was under three different managements, i.e., the Aomori-Tokyo section operated by Japan Railway Company, Tokyo-Kobe section by the government Railway Bureau, and Kobe-Hiroshima section by San'yō Railway Company, the standards of their tracks and rolling stock were basically unified,

TABLE III

	Troops (Persons)	Horses	Freight (Tons)	Kilometerage of Train Runs
Outgoing (Feb. 1904–Oct. 1905)	886,012	138,350	262,026	1,997,094
Incoming (Oct. 1905–May 1906)	398,887	62,476	60,888	656,441

Source: Transport Department, Railway Work Bureau, *Meiji 37-8-nen sen'eki gunji yusō hōkoku* [Report on military transport during the 1904–5 war].
Note: The incoming figures do not cover the total number of troops pulled out. The kilometerage of train runs have been translated from mileage.

thereby making possible direct train service all the way from Aomori to Hiroshima.

Whereas specific demands made by the military concerning railways will be referred to collectively elsewhere in this paper, it is pertinent to note here that this direct train service enabled troops to be efficiently shifted across the country.

The military built a sidetrack from Shinjuku station of Japan Railway Company's Yamanote Line, encircling the urban area of Tokyo, to the Aoyama Drill Ground (the present-day outer garden of the Meiji Shrine), which was made a transit point for troop transport. This step was taken presumably because of the absence in those days of a track directly connecting Ueno and Tokyo Central Station. Further at Shinagawa station, the junction between the Yamanote Line and the Tōkaidō Line, and at Yokohama station, where switchbacks had been used, the Army built on a makeshift basis direct lines between Ōsaki and Ōimachi and between Kanagawa and Hodogaya to bypass Shinagawa and Yokohama, respectively, and thereby eliminated the losses of time resulting from the switchbacks.

The latter bypass, in particular, became part of the main line after the war, and the position of Yokohama was reduced to one of a local line station.

Although no statistics on transport during the Sino-Japanese War are available, it is certain that the efficient rail transport system enable large troops to concentrate in the departing port of Hiroshima in a short period of time.

In contrast, statistics are available, as tabulated below, on transport by the government-owned railways during the Russo-Japanese War.

The war involved the enormous transport of an aggregate of one million troops and moreover, mobilizations were concentrated at the beginning of the war and immediately before major battles. Therefore, it was impracticable to run military trains between scheduled civilian trains, and two different train schedules were formulated to meet wartime transport needs. One was the ordinary schedule giving priority to civilian trains, and the other a special schedule permitting military trains to override civilian needs. The latter provided, for instance on the Tōkaidō Line, for the daily operation of fourteen military trains in each direction, eastbound or westbound, at equal intervals and at an equal speed.

This military transport operation demonstrated the sufficient flexibility of the railways to satisfy massive transport needs in an emergency. Particularly, in view of the complexity of the Japanese railway network in those days in which state and private tracks were intricately intertwined with one another, the achievement of such efficient transport is simply amazing. (Learning a lesson from their experience during the war, Japanese railway operators from 1906 on made it their usual practice to draw lines for military trains first in preparing train schedule diagrams, so that military trains could be operated any time required without altering the schedule of civilian trains.)

III. BACKGROUND OF TECHNOLOGICAL INDEPENDENCE (2)

The increase in transport needs described above undoubtedly constituted the basis for the acceleration of Japan's elementary mastery of railway technology. In short, the factors referred to in the foregoing chapter necessitated the early establishment of a system of massive and fast transportation.

The capability for massive and fast transportation is the intrinsic function of railways as a means of conveyance. Because of this capability, the railways came into their own along with the progress of the industrial revolution, which in turn was accelerated by this railway development. Here we find a correlation between the industrial revolution and the development of rail transport.

The Japanese railways, however, were not the by-product of the industrial revolution, but the outcome of a political requirement to establish a centralized administrative organization. This initial motive long remained at the root of and conditioned the subsequent development of railways in Japan.

The strong impact of the military requirement, which contributed to the full technological independence of the Japanese railways, seems also to have reflected this political undercurrent. The technological independence further required a unification and standardization of techniques. The factors contributing to this will be analyzed in the following sections. On that basis, the progress of standardization will be traced in the next chapter.

A. *Need for Control over Private Railways*

It is well known that, when railways began to be built in Japan, the government wanted them to be "state-owned and state-operated." It also applied this policy to other means of communication such as post, telegraph, and telephone. To achieve the objective of strengthening the centralized administrative system, it was considered indispensable for the government to establish and operate the means of transportation and communication for itself. The telegraph service, which was an extreme example, was initially operated under the principle of giving priority to governmental and military usage and "permitting private utilization only when there is time to spare."

Initially, the planning of private railways was considered unfeasible, even out of the question, both in view of this policy of the government and because of the limited financial means of private interests. However, since the construction of Tokyo-Yokohama and Osaka-Kobe railways cost more than expected and the government could not afford to build their extensions, a proposal was made to collect private funds to construct more railways.

The government intended to have commercial capitalists in the Kansai region, mainly the Mitsui, Kōnoike, and Shimada, traditionally wealthy merchant families since the Edo period, set up a Kansai Railway Company. In Tokyo, noblemen organized the association of peers, which planned to purchase from the government and operate the Tokyo-Yokohama railway.

The former attempt proved abortive. The latter, too, failed to bear immediate fruit, but eventually resulted in the founding of Japan Railway Company in 1881, with its capital collected from peers and former samurai, who, deprived of the stipends they had received under the Tokugawa regime, were paid a sort of retirement compensation in public bonds obliging them to have some vocation or other. However, the inflation which ensued from the civil war in 1877 reduced the bonds to little more than mere pieces of paper. Thus, the holders of these bonds could no longer embark on new careers or sustain themselves until they found jobs.

Under these circumstances, Tomomi Iwakura, then in charge of the affairs of the peerage at the Department of the Imperial Household, recommended the association of peers to utilize its organization and set up a railway company. The idea was to have its members deposit their bonds with the Fifteenth National Bank, the government would extend financial assistance with those bonds as security, and the railway company would be established, mainly financed with investments by the bank.

The government thus approved the founding of a private railway company as an exceptional case. Whereas this Japan Railway Company, as its name suggests, had as its target the building of railways in all parts of the country, for the time being it took charge of the construction of the easternmost Tokyo-Takasaki section of the Nakasendō trunk line and the Tokyo-Aomori line which the government had planned.

In this case, the government adopted a policy of undertaking the construction of the tracks for itself, having local governmental agencies purchase the required sites, and extending an interest subsidy to the company. In short, the role of the company was nothing more than to supply funds, and accordingly the materials it purchased as well as its facilities and rolling stock all conformed to the same standards as the government-owned railways.

The private railway company, contrary to the anticipation of most observers, earned large profits because, as a result of the connection of its Tokyo-Takasaki line to the Tōkaidō line at Shinagawa, the Yokohama-bound shipments of raw silk from Gumma and Nagano prefectures concentrating in Takasaki and Maebashi, both of Gumma Prefecture, almost wholly shifted to the new railway from their former dependency on the Nakasendō highway or the Tone River. Moreover, from 1885 to 1886, the farm population of Japan became disintegrated, and manpower began to concentrate in cities. At the same time, capitalist enterprises started to quickly increase their investments mainly in the newly emerging spinning industry.

It was on account of these developments that entrepreneurs planning private railway ventures emerged in many parts of the country. Most of them were mere speculators, wishfully counting on financial aid from the government or intending to profiteer by selling shares, but in any case there came into existence a number of railway companies operating San'yō, Kyūshū, Kōbu (Iidamachi-Hachiōji), and Kansai (Nagoya-Osaka) trunk lines.

Their combined kilometerage reached 840 by 1889, which was nearly comparable to 881 belonging to the state-owned railways, and by 1890, they far surpassed the latter with 1,357 kilometers of track. From then on, private railways rather constituted the mainstay of rail transport in Japan.

These private railways, however, imported technology from different sources. Kyūshū Railways, for instance, invited engineers and purchased material supplies from Germany. In Hokkaidō, the railway for coal transport from the Horonai mine to the Port of Otaru was undertaken by the Commission for Hokkaidō Development. From the very beginning of the project, the technology used was from the United States which had been deeply involved in the development of the region. Even after the railway was sold to a private concern, namely Hokkaidō Coal Mine Railway Company, it continued to be managed in the American way.

In the state-owned rail network itself, technology and materials from the United Kingdom, Germany, and the United States began to be mixed, as rails and other material needs were increasingly imported from Germany and the United States, both threatening the previously dominant position held by the United Kingdom in the world market.

It was feared, however, that the above situation would lead to the disintegration of the Japanese railway system, and the government found it of urgent necessity to tighten its control over private railways.

B. *Establishment of Governmental-Military Leadership in Railway Policy Making*

The military, rather than the government, was explicit in urging tighter control. Though it had shown a negative attitude toward the early construction of the railways when they were first proposed, the military took note of the remarkable efficiency of the Tokyo-Yokohama railway in the transport of troops which upon arrival in Yokohama were then sea-borne from that port to Kyūshū on the occasion of the civil war in 1877. In 1879, the Army conducted a detailed survey of the transport capacity of the railways. The Army switched from the French system to Prussian style organization, presumably having learned a lesson from the effective use of railways by the Prussian army in quick transfers of its troops during the Franco-Prussian War. The charter given to Japan Railway Company when it was founded in 1881 provided (in Article 24), "In the event of an emergency or a war, the company shall have the obligation to allow the government, if so ordered, freely to use its railways."

Further in 1884, it was formally decided that construction of new or improvement of existing railways was subject to consultation with the Army by the directive of the Cabinet (addressed to the Minister of Industry), dated February 25, saying, "Since construction or alteration of railways has bearing on military affairs, consultation should be made with the Ministry of War to discuss how it is to be executed." The insistence of General Aritomo Yamagata, an elder of the Army, on the Nakasendō routing in choosing the course for the Tokyo-Osaka-Kobe trunk line, which was touched on earlier, was not unrelated to this decision.

Thus, the Army secured a strong voice in the construction and improvement of the railways. On May 18, 1887 was promulgated the Private Railway Ordinance, which provided a legal basis for the unification of the standards of private and state railways.

By that year, the military had made up its mind and begun full-scale preparations for a war with China under the Ch'ing dynasty. Its consent, in July the year before, to the Tōkaidō routing of the trunk line at the enthusiastic persuasion of Director-General Inoue of the Railway Bureau seems to have reflected its decision to move ahead from a "defensive" to an "offensive" posture.

Furthermore, the Army was contemplating a more positive way of utilizing the railways for military purposes. In June 1887, a month after the promulgation of the Private Railway Ordinance, the Joint General Staff of the Army and Navy presented, in the name of its chief, Prince Arisugawa-no-miya Taruhito, a proposal to Inoue, the railway chief. Pointing out the potential danger involved in the routing of the trunk railway partly running along the coastline, the general staff proposed that another trunk line should be built across the inner parts of Honshū and Kyūshū. Because the current 3′6″ (1,067-mm) gauge was inadequate for the massive transport of troops, the proposal said, the new trunk line should instead have a gauge of at least 4′8-1/2″ (1,435-mm) and be double-tracked throughout.

Inoue replied he was not in favor of immediate implementation of the Army-proposed improvement, which would cost an enormous sum of money, but the railway chief, who was strongly opposed to the development of private railways, was not outrightly against the proposal.

In April 1888, the Army Department of the General Staff released a treatise entitled "A Theory on Railways," in which were listed a number of steps that could be taken for the utilization of the railways by the military. It thereby tried to promote an understanding of the military functions of railways both within and outside the government. Notable points of the treatise included the assertion that the Army should be allowed a voice in all aspects of railway policy and that decisions on trunk line projects, double-tracking of existing lines and improvement of existing stations and other facilities should satisfy military requirements.

There is no way of knowing what reactions this proposal brought forth, but every year from 1890 on, the Army and Navey held annual grand maneuvers, and the transport of troops constituted an important part of the yearly event. To facilitate loading and unloading of gun carriages and other military equipment, the platforms were aligned in height with the freight car floor and inclined at both ends. Obviously these modifications reflected the desire of the military.

At the same time, both state and private railways, except such purely local ones as trolley lines, were unified in gauge, and so were the basic standards of passenger and freight cars. It was not before the turn of the century that these standardizations were given a legal basis, and until then there were a series of developments including the enactment of the Railway Construction Law in 1892. In the following chapter will be discussed these problems, with primary emphasis on the process leading to the completion of standardization.

IV. PROGRESS OF STANDARDIZATION

On June 21, 1892, the Railway Construction Law was promulgated. The law provided for the governmental designation of projected railway routes that had to be built in the future. In the first-phase of the construction of these projected lines there were in particular, nine urgently needed ones to be constructed in twelve years. The funds required for this project were to be defrayed from a special account and public bonds, totaling not more than ¥60 million, could be floated in that connection over the twelve-year period. The law further authorized the government to take over private railways and to permit private interests to build railways along projected lines, subject to the approval of the Diet, with the government reserving the right to take them over subsequently.

The legislation was epoch-making in that it established a basis for a strong governmental initiative in railway policy making. The years before, in 1890, the capitalist economy was beset with its first panic, and some private entrepreneurs asked the government to nationalize their railways. In view of this situation, Director-General Inoue of the Railway Agency (the Railway Bureau had been transferred in 1890 from the Cabinet to the Ministry of the Interior and so renamed) intended to take that opportunity to nationalize all private railways and in 1891, submitted to the Minister of the Interior "a proposal on railway policy."

Inoue's proposal triggered the enactment of the Railway Construction Law. There were moves against nationalization both in and out of the government, especially among Diet members who represented local interests, and the resultant legislation did not fully reflect Inoue's initial intention. The law nevertheless established the legal basis for the governmental-military initiative and thereunder was founded the Railway Conference among other things. It was a supreme advisory body to the Cabinet with respect to railway policy making and was supposed to be chaired by the Assistant Chief of the General Staff. In the conference were also represented the Diet and capitalists, but it was so organized that the representatives of the military, government, and bureaucracy could hold the majority and override the voices of other groups.

With a turning point marked in 1892, the state control over private railways was given a legal footing. The relationship between the perfection of technological independence and the progress of standardization, which is the ultimate theme of this paper, developed, conditioned by these circumstances, under the leadership of the government and the military.

In this connection, the writer would like to take up three sub-themes in this chapter. The first is the problem of standardization in the period immediately preceding and following the enactment of the Railway Construction Law. The second is that of standardization under the Railway Operation Law promulgated in 1900. This legislation marked the perfection of the legal basis for the standardization of the railways. The third is that of gauge alteration. The gauge problem, which remained an important issue to the Japanese railways and continued to be discussed for a long time even until the opening of the New Tōkaidō Trunk Line (Shinkansen) in 1964, indeed had its origin in those years.

It is the intention of the writer to elucidate the relationship between the technological independence and the progress of standardization through an analysis of these sub-themes.

A. *Technical Standards in the Latter Half of the 1890s*

With particular reference to the construction aspect, specifications on curves, grades, and track structure had previously been determined on an ad hoc basis in most instances, partly because the techniques introduced by British engineers had been directly followed. As a result, not only the track standards but also the tunnel cross-section and bridge strength sometimes failed to match the natural features of Japan.

In 1886, however, the routing of the Tokyo-Kobe trunk line was altered from Nakasendō to Tōkaidō, and moreover, a severe time limit was imposed on its construction; the 500-kilometer railway had to be completed in about three years. Railway Bureau Chief Inoue tried to solve the problem of the time limit by dividing the whole line into a number of sections, which were to be separately built at the same time. Had different track standards been used in different sections, gaps in transport capacity would have occurred between some parts of the railway and others.

It was, therefore, prescribed that the minimum radius of curvature should be 20 chains (about 400 meters) and the steepest grade 10/1,000 on plains or 25/1,000 in mountainous areas and that an auxiliary locomotive should be connected to the train in mountainous sections (specifically the Kōzu-Gotemba and Ōgaki-Kashiwabara sections in addition to the already built Ōtsu-Kyoto section) to prevent a drop in transport capacity. To span the Fuji, Abe, Ōi, and Tenryū rivers flowing from the central mountainous region into the Pacific, 800 to 1,000-meter long bridges were required, and their construction, except in the case of the bridge on the Abe River, was accelerated by the use of 200-foot double Warren trusses. The load bearing capacity of the bridges, which had matched the 11-ton axial load of locomotives, was raised to 14 tons with a view to increasing the transport capacity, to which the advancement of standardization also contributed.

As regards tunnel standards, too, the maximum arch width was expanded from the previous 14 feet (4.3 meters) to 15 feet (4.6 meters), and the height from the formation level was increased from 15 feet 6 inches (4.7 meters) to 16 feet (4.9 meters).

This progress in standardization enabled the Tōkaidō Line to be efficiently built in a relatively short period of time, facilitated maintenance of structures, and helped achieve a uniform transport capacity over the whole length of the line.

The project was accomplished of course without the guidance of any foreign engineer. By that time, a number of graduates having learned the fundamentals and applications of civil engineering at the Imperial College of Engineering or its successor, the College of Engineering of the Imperial University (the present-day School of Technology of Tokyo University), had been employed every year by the government as engineers, and appointed to field positions responsible for supervision of the execution of construction work. The techniques which previously had been learned from hired foreign engineers through practical experience were now integrated into systematic knowledge through basic theorization, and accordingly made adaptable to a wide range of related fields.

For technicians assigned to direct field duties as well, a new training method came into use to have them learn practical knowhow as applied techniques deriving from a certain theoretical basis. This method was used not only for civil engineering technicians but more conspicuously for personnel engaged in the operation, repair, or maintenance of rolling stock. They received forced education with textbooks briefly covering an extensive range of knowledge from basic theory to applied techniques and were able to utilize it immediately in the field.

Thus were made arrangements to have technical personnel of all levels, from sectional superintendents to field technicians, follow a unified technical system, and in this sense there seems to have been in progress "the standardization of techniques," too.

This unification made both governmental and private railways conform to common standards. It was in part the result of the aforementioned requests of the government and the military. It was also in part due to the unification of training bodies for railway engineers, including above all the Imperial University College of Engineering, and its curriculum, together with the circumstance that the same engineers often took charge of construction for different railway companies. Thus developed the simultaneous progress of technical mastery and standardization.

B. *Legalization of Standards under the Railway Operation Law*

During the 1890s, the need to accelerate construction and expand transport capacity stimulated the progress of standardization, and a number of regulations applicable to state railways were enacted, such as the Civil Engineering Regulations (1893), Railway Bureau Tunnel Regulations (1894), Architectural Regulations (1898), and Station Regulations (1900). But no steps had as yet been taken to impose legally based, unified standards on private railways.

In the meantime, however, the government had been conducting a preliminary survey for the prescription of minimum standards applicable to all domestic railways, whether state or privately owned. On March 16, 1900 were promulgated the Railway Operation Law and Private Railway Law, and Article 1 of the former provided, "Construction of any railway and the structure and operation of rolling stock and equipment therefore shall conform to rules prescribed by Cabinet orders." Railway standards, if stipulated by legislative action, would have failed to adapt to the continual progress of technology. It was for this reason that the government elected to prescribe them by Cabinet orders, which were up to the government to amend or abolish. The Private Railway Ordinance, which had previously set forth standards for private railways, was at the same time transformed into the Private Railway Law. Instead of having this law directly stipulate standards for private railways, it was provided that the rules under the Railway Operation Law should govern both state and private railways alike.

On August 10, 1900, the Railway Construction Rule, Railway Signal Rules, Railway Transportation Rule, and Railway Statistics Rule were formulated, and brought into force on October 1, the same year, together with the Railway Operation Law and Private Railway Law.

Before drafting the Railway Construction Rule, Railway Chief Engineer Ryūtarō Nomura went to England in vain to find a suitable model for it. He further visited Berlin, where he prepared a draft with reference to the German Railway construction rule. He was assisted in this by Shōhei Tanaka, train section chief of Japan Railway Company, then staying in the German capital (Tanaka is also known as the inventor of the harmonium). The rule so spelled out set the rail gauge at 3 feet 6 inches (1,067 mm), maximum grade at 25/1,000 (prohibiting any steeper grade than 40/1,000), minimum radius of curvature at 15 chains (about 300 m) and minimum load endurance of track at 10 tons per car. It also stipulated standards on rail weight, ballast depth, minimum platform width, effective length of main track in stations, track center spacing, bridges, and tunnels. It further prescribed the construction gauge and rolling stock gauge for the first time and thus defined the relationship between railway structures and rolling stock.

The characteristic of this rule was that it theoretically restructured the European railway design standards to suit the transport situation in Japan, prescribing a 1,067-mm gauge among other things. The standards it provided for grades, curves, vertical curves, track center spacing, load endurance of tracks and bridges, construction gauge, and rolling stock gauge were all based on calculations. Railway construction standards were thereby unified and in addition, technical standards meeting the peculiar transport needs of Japan were established.

Standards were similarly unified for operations, signals, and maintenance. Principles were thereby integrated with respect to the following: maximum operating speed, propulsive speed, speed in passing a curve accompanying a shunt, through track, shunting equipment, maintenance and inspection of stations and rolling stock, marking of rolling stock, number of brakes required per train, installation of continuous brakes, block system, signals and their handling, and interlocking plant.

The standardization so achieved enabled direct train services to extend over both state and private lines and to satisfy the military need in this respect. Governed by these rules, every railway endeavored to expand its transport capacity. To cite a few examples of these endeavors: San'yō Railway Company did not allow any of the grades on its line to exceed 10/1,000 except for a 22.5/1,000 one between Hachihommatsu and Seno; the state railway began planning a project to improve its Tōkaidō Line by eliminating the aforementioned continuous 25/1,000 grades in some of its sections; the state railway took its first step toward increasing the rail weight by deciding on the use of 60-pound rails conforming to the standards of the American Society of Civil Engineers (ASCE). Furthermore, 75-pound rails in heavy traffic sections of the Tōkaidō Line were used, and Japan Railway Company began to use large Mikado type locomotives, the world's first to have the 1D1 shaft arrangement for coal transport from Iwaki.

C. *Problem of Gauge Expansion*

The use of the narrower-than-standard 3′6″ (1,067 mm) gauge by the Japanese railways proved a basic impediment to increasing transport capacity. For this reason, arguments urging a gauge expansion to or even beyond the international standard of 4 feet 8-1/2 inches (1,435 mm) were repeated over again from late in the 1880s until the first decade of this century. The first to demand this improvement was the Army.

"A Theory on Railways" by the Army Department of the General Staff, earlier referred to, emphatically called for the use of the international standard gauge for military reasons. The military, especially the Army, repeated this urge on subsequent occasions. In 1893, Lieutenant General Tateki Tani, a member of the Railway Conference, demanded an expansion of the railway gauge, again for military reasons.

After the Sino-Japanese War of 1894–95, along with the development of a capitalist economy in the country, the use of a wider gauge was once again urged, this time by private businessmen. In 1896, the government set up a rail gauge inquiry committee in the Ministry of Communications, which then had controlling authority over the railways, and had it study the relative advantages and disadvantages of wide and narrow gauges, and conceivable ways and estimated costs of widening the gauge. The General Staff strongly insisted on gauge expansion.

Within the Ministry of Communications, however, the tide was not in favor of an early expansion of the gauge because of its prohibitively high costs (estimated at about ¥173 million in total, close to the annual state expenditure in those days of some ¥200 million, of which military spendings accounted for 40 to 50 per cent), and the inquiry committee was dissolved in 1899. Moreover, Major Kaiyū Ōsawa of the Army, who had been sent to Europe to study military transportation, came back and published a treatise denying the importance of the railway gauge to the efficiency of military transport. Rather than expanding the gauge, improving the facilities and rolling stock, with the gauge left intact, could be sufficiently effective to raise the efficiency of military transport, Ōsawa wrote. His opinion had the impact of gradually discouraging the advocates of a wider gauge in the General Staff, and gauge expansion was no longer proposed until after the Russo-Japanese War of 1904–5.

The government nevertheless used the international standard gauge for the railways it built in Korea, between Seoul and Inchon and between Seoul and Pusan. The government presumably wanted to match the gauge used in Korea with that of the railways it had already been constructing in China. It was for the same reason that the South Manchuria Railway, the interest in which had been taken over from Russia after the Russo-Japanese War, was narrowed to the international standard gauge from Russia's five-foot (1,520-mm) standard. Interestingly, when she began to build railways, Russia deliberately used a wider-than-standard gauge with an eye to preventing invasion by European troops, and extended her wide-gauge railway in Siberia into the Northeastern region of China.

The aspiration of Japanese technocrats "to realize in continental Asia the technology that cannot be realized in Japan" found no exception in railway technology.

V. CONCLUSION

The writer has briefly reviewed the process that led to the technological independence of the Japanese railways during the period in which a capitalist system was established in this country. This writer has also pointed out that standardization in various aspects made remarkable progress over the same period. Technological independence certainly was the target that the Japanese railway people set for themselves from the outset, and its achievement in three brief decades undoubtedly was a great success for that matter.

The process of standardization which made headway side by side with technical mastery was significant in that it was realized by the Japanese for themselves. Once they were "given" the rail gauge, one of the most fundamental factors, at the very beginning of their railway service, imported standards on facilities and rolling stock were accepted like something predetermined. As a result, there arose all kinds of confusion in the early phase. The Japanese, however, advanced standardization for themselves, first through empirical knowledge and then based on a theoretical system. This process of standardization linked itself with a determination to achieve technological independence.

In this sense, too, the process toward technological independence and that of standardization were synchronic developments. What made this synchronic progress possible was the independent thinking of the Japanese engineers. However, as pointed out earlier, those who played the central role in promoting and perfecting this process of standardization were the military and the government. These power mechanisms, moreover, little reflected the will of the populace in spite of their modern appearance.

Standardization essentially starts from a certain way of rationalism that the capitalist economy demands. This was characteristically true with classical modern states. Meiji Japan of course sought thorough rationalism in its governing mechanism, military structure, and armament. A typical example of synchronic progress in the area of technological self-help and standardization could be found, before the Sino-Japanese War, in the Army's unified use for its infantry of the Murata repeating rifle. This was a uniquely Japanese invention which, together with the bullets, the Army succeeded in producing locally. The pursuit of rationalism was given the greatest emphasis by the military, whose rationalism, however, was unrelated to the needs of the emerging capitalist system, which in turn was linked less with the popular awareness of human rights in modern civil society than with the aspiration of the state power to make inroads into the Asian continent.

There was formed a path to standardization, as it were, *von oben* (from above). This obviously is an essential element of rationalization and standardization under a capitalist system, but in Meiji Japan standardization by the state preceded and even guided that required by the capitalist economy. It was a typical specimen of standardization at the initiative of the state following the tradition of "increase production and promote industry" policy. Perhaps it may be considered that this pattern of standardization definitely manifested one of its characteristic aspects in this perfection phase of technological independence. And the nationalization of the railways may be further regarded as the manifestation of this characteristic in its ultimate form. It is not the purpose of this paper to elaborate on this nationalization which was legalized in 1906 and fully implemented the following year. But is it unreasonable to see the government's desire for the ultimate unification of standards in its takeover of seventeen private railway companies including Japan Railway Company, San'yō Railway Company, and Kyūshū Railway Company? Not only had these constituted an important network of trunk lines in Japan, but also, the government no longer permitted private interests to operate railways except for strictly local lines.

Obviously, the nationalization of the railways was realized to achieve just one purpose. As mentioned above, some private operators were so easygoing as to request of the state that it took over their railways in time of business stagnation. There emerged a specific plan for nationalization shortly after the Sino-Japanese War, and in the middle of the Russo-Japanese War the government, viewing the international position and domestic situation of postwar Japan, finalized its policy of nationalizing the railways. It had no regard for the position of private railway management.

Along with the facilitation of transport and the reduction of fares, the third expected benefit of nationalization claimed by the government was the unification of equipment. "*The outline of the purport of railway nationalization*" which stated the government's view on this subject referred to that particular point, saying, "By unifying the different types of rolling stock and various materials now belonging to individual railways, the benefit of their common use by different lines will be achieved, and there will be no little contribution to the convenience of transport operations in the future" [1, p. 153].

Thus in the nationalization of the railways at the initiative of the government, standardization was looked forward to as one of its major effects. The fundamental objectives, technological independence, and standardization were pursued to perfection. It is in this respect that the basic characteristics of the Japanese railways are found during the decades under review.

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